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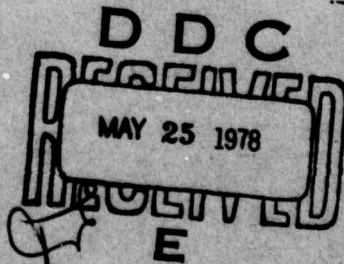
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1.0 PROGRAM DESCRIPTION

Beginning in fiscal year 1971, the Space and Missile Systems Organization (SAMSO) tasked the Air Force Geophysics Laboratory* (AFGL) to forecast, sample, and report on a range of ice/water particle (hydrometeor) environments which would be applicable for testing the erosion characteristics of hypersonic payloads launched from NASA Wallops Flight Center (WFC). SAMSO would provide and launch the payloads while the Meteorology Division of AFGL would provide meteorological support to the Advanced Ballistic Reentry Systems (ABRES) office of SAMSO. Science Applications, Inc. (SAI), under contract to AFGL, provided AFGL program assistance for launches conducted during the winter storm seasons of FY76 and FY77.

The launches conducted in FY76 fell under the auspices of the Sandia Air Force Materials Study (SAMS), while those conducted in FY77 were performed under the Materials Screening Vehicle (MSV) study. Although both studies were concerned with determining the erosion characteristics of their respective payloads, the payload trajectory differences necessitated using different testing philosophies.

The SAMS launches were concerned with measuring the erosion effected by a hydrometeor environment on a "reentry vehicle" (RV) as its 3-stage, Talos-Terrier-Recruit (TATER), booster rocket ascended hypersonically through a weather system approximately 20 nm east of Wallops Island. The proximity to NASA's Space Range Radar (SPANDAR) permitted simultaneous radar and aircraft instrument sampling of the air mass after it was traversed by the "RV".

The MSV launches were concerned with measuring parameters identical to those measured during the SAMS launches, but in this study the payload was three mini-RVs, simultaneously descending through a weather system over water approximately 75 nm east of

* Formerly the Air Force Cambridge Research Laboratories (AFCRL)

Wallops Island. At this distance, simultaneous sampling of an air mass with SPANDAR and aircraft instrumentation is not especially effective due to the poor resolution of the radar height data. For the MSV launches, these simultaneous measurements had to be made prior to launch as the storm system passed near Wallops Island. Therefore, launching the payload was keyed on the hydrometeor environment encountered in the storm system and the forecast position of this environment as it neared the calculated trajectory of the three mini-RVs.

1.1 PROGRAM OBJECTIVES

The objective of both the SAMS and MSV programs was to determine the erosion characteristics of newly developed nosetip and sidewall materials and/or of the fabrication methods associated with traversing a measured hydrometeor environment. The term "hydrometeor" refers to all of the liquid, solid, and mixed phases of condensed water existing in the atmosphere. It includes a spectrum of particle sizes from tiny ice crystals and cloud droplets through the various forms of snow, to the larger forms of liquid precipitation.

As an indirect benefit of the primary objective, the programs were expected to provide data for a more comprehensive understanding of hydrometeor erosion factors through the utilization of more refined and effective aircraft sampling and radar data. These additional data should also aid in the development of more realistic hydrometeor models for inputs to erosion codes for reentry vehicles.

2.0 SAI TASKS

Science Applications, Incorporated tasks included the following:

- 1) Develop meteorological and operations plans
- 2) Assist in meteorological analysis before the missile launch countdown commences
- 3) Provide coordination of meteorological sampling aircraft using NASA/Wallops Flight Center facilities
- 4) Provide real time analysis for dissemination of meteorological parameters collected by sampling aircraft
- 5) Assist in the post-launch data collection and preliminary analysis to provide an initial environmental definition profile of water content.

SAI completed all of its assigned tasks in an orderly, timely and professional manner, while exercising continuous mutual cooperation with all program participants. Cooperation was constantly required to compensate for program variables such as: aircraft status, flight icing levels, ground equipment malfunctions, FAA directed increases and decreases in usable flight levels and range space, and the minute detailed weather monitoring required prior to, and after, the successful mission launches.

2.1 METEOROLOGICAL AND OPERATIONAL PLAN

The development of a meteorological and operational plan was mandatory, and the evolution of the final Plan encompassed several drafts and revisions.

2.1.1 Early Drafts

Early drafts were assembled piecemeal as the many facets of the program became evident. The numerous organizations involved had their roles defined with ever increasing accuracy as preparation for testing progressed. It was SAI's task to expand on the initial AFGL draft and incorporate the substantive changes that were evolving within the program.

2.1.2 The First Plan (FY76)

The first plan was completed on 10 October 1975, and, as in any working document, it was promptly revised and corrected when testing began. It was supporting both a SAMS and an MSV launch into the same storm, although this never actually occurred.

2.1.3 October 76 Edition

The final plan supporting MSV only and deleting any SAMS support was published by SAI on 15 October 1976 and was the culmination of extensive experience gained by testing and employing the previous plans.

2.1.3.1 The Plan, a "Working" Document

Development of the Plan was consistent with the growth of any working document. The interrelationship of the many organizations, the limitations of the personnel and the hardware, and the constrictions of on time, money, and other resources all contributed to the refinement of the Plan.

2.1.3.2 Final Revision

As the FY77 season progressed, the Plan showed that, as a working document, it continued to reflect the dynamic aspect of the test program. For example, the detailed flight patterns, elaborately presented in the Plan, were not adhered to with any consistency. Based on the premise of reasonable homogeneity of the storm conditions, the precise patterns were not applicable to the spotty and marginal conditions which were found to be the rule rather than the exception in actual testing. Thus, a "final" revision would reflect changes that the employment of its predecessor generated, ad infinitum.

2.2 PRE-COUNTDOWN METEOROLOGICAL ANALYSIS

Dr. J. E. Cockayne, SAI, as Assistant Field Director (AFD) to the AFGL Field Director (FD), was required to continuously monitor storm conditions prior to each launch. Storm systems had to be analyzed for intensification, filling, and movement to insure the payload would be exposed to environments meeting the stringent launch criterion.

2.2.1 Analysis Tools

In order to best determine or select those storms which would provide optimum payload environments, many meteorological "tools" were available to aid in the decision process. Satellite photographs, National Weather Service (NWS) synoptic maps and upper air soundings and four meteorological radars from surrounding sites were employed on a real time basis beginning at T-4 hours. Further, NWS personnel provided additional briefings and upper air soundings as they were required for more detailed synoptic analyses. All of these input parameters were carefully weighted and analyzed during the time frame preceding the actual storm sampling.

2.2.2 Benefits of Pre-Countdown Analysis

The success of the required pre-countdown meteorological analysis is attested to by the results encountered in the operational phase of the program. In the FY76 test period three SAMS missiles were successfully launched, and two successful launches of the MSV missiles followed in FY77. In addition, much valuable data was collected during thirteen sampling missions that were initiated in which the weather failed to meet launch conditions. It is evident that pre-launch analyses proved to be extremely effective.

2.3 AIRCRAFT CONTROL

The use of aircraft for in-situ sampling of airborne hydrometeors presents a complex problem of aircraft control. This is especially true when two aircraft are simultaneously sampling in the same storm system. Aircraft control is necessitated for two reasons: 1) flight safety is of paramount importance in any operation involving aircraft in weather, and 2) precise locations (latitude, longitude, and altitude) and flight patterns are required in order to optimize sampling operations and aid in subsequent data analyses. Precise flight plans were drawn up for the "ideal" storm situation but, as mentioned previously in Section 2.1, deviation from the prescribed operational flight plans was the norm.

2.3.1 Track Display

Range and azimuth of the aircraft from SPANDAR were displayed on an XY plotboard located in the Weather Operations Control Center (WOCC). Two similar maps, one for each aircraft, were placed on the plotboard and a pen traced each aircraft's position and motion independently. The Aircraft Coordinator (AC) thus had visual positional aircraft data to safely effect separation at all times.

2.3.2 Communications

VHF (123.3 MHz) was the prime aircontrol frequency used between pilots of both aircraft and the AC, with a backup capability provided by additional VHF/UHF frequencies. The AFD sat adjacent to the AC and flight pattern instructions, requested by the AFD for mission support, were relayed to the pilots via voice. The AFD also manned a discrete frequency for communication with the aircraft Flight Meteorologist (FM). The AC provided positive control for all mission aircraft during operations that were conducted primarily within the W-386 warning area. Safety of the aircraft operations was further enhanced by NASA radar which continuously monitored the operational mission area for "Intruders". One instance of unidentified traffic on the range was

recorded in the 76-77 winter by NASA ASR-7 radar. The radar operator alerted the AC but the transient "aircraft" was opening from mission aircraft at a distance of approximately 60 miles.

2.3.3 Other NASA Support

In addition to the plotboard and associated radar and communications, NASA provided for Range clearance and other-than-normal duty hour maintenance of the above facilities.

2.3.3.1 Range Control

At the suggestion of SAI, NASA Range Control obtained Range Clearance for MSV program aircraft and defined it in writing. However, these range clearances were subject to rescheduling by higher-priority programs and, at times, the MSV program aircraft were restricted to only the western half of W-386, i.e., W-386A. Most of the aircraft operations were within 60 nm of the ASR-7 radar which was located in Bldg N-159 at Wallops Station.

2.3.3.2 Duty Hours

"Normal" duty hours at Wallops Flight Center were weekdays 0800-1630L, but for practical purposes no earlier than 0900L and no later than 1600L, with minimum support 1130L to 1300L hours. At other times, NASA support was called in on an overtime basis and provided cheerful support - except for early in the program when a series of MSV launch attempts were cancelled. Understandably, NASA personnel often hastened to shut down, creating problems for the Aircraft Coordinator who had the responsibility for tracking aircraft until they were off the range and also had to maintain communications for the remainder of the mission. Coordination between NASA and program directors alleviated this problem, with NASA providing support until conclusion of all air operations.

2.3.4 NWS Support

The required aircraft support by SAI included a periodic evaluation of their in-flight status. To satisfy requirements, the enroute weather and landing data forecast for the C-130E* out of Wright-Patterson AFB (WPAFB), Ohio, were provided by the NWS staff. Further, NWS personnel assisted in preparing assessments of icing conditions throughout the storm system in order for the Learjet pilot to expedite his ascent/descent if appropriate.

2.4 MISSION CONDUCT

Prior to missile launch, the mission was conducted by correlating aircraft sampling data with data acquired by radar (SPANDAR). Decisions regarding coordinating data acquisition were made on a real time basis.

2.4.1 Assistant Field Director

During the entire mission, Dr. J. E. Cockayne, acting as the AFD, maintained radio communications with the Flight Meteorologists and voice communication with the Field Director and Aircraft Coordinator.

2.4.2 Weather Data

Weather data were recorded continuously by each sampling aircraft, but the decisions of where to fly (range, azimuth, and altitude) was an on-going process, made on a minute-to-minute basis by Dr. Cockayne in conjunction with the FD. Verbal observations made by the Flight Meteorologists, meteorological data recorded by SPANDAR and transmitted to the WCCC via closed-circuit TV, and Patuxent and Hatteras meteorological radar data were used in the mission analysis.

* In late 1977, this meteorological research aircraft was designated MC-130E; this report only uses C-130E and C-130 designations.

2.4.3 RADAR Correlation

Early in the FY77 season, a procedure was used to correlate the data gathered by one aircraft with SPANDAR data by SPANDAR tracking the aircraft. This required the other airplane to "wait" for its turn. Early on, the procedure was modified to provide for the waiting aircraft to collect data on a controlled basis, albeit it was not correlated with SPANDAR. This modification, another example of the dynamics of a working document, provided a substantial increase in the amount of useful data obtained on a particular mission.

2.4.4 Storm Analysis

The resultant thorough analysis of the storms hydrometeor environment enabled the FD and AFD to properly advise the ABRES Mission Director regarding the storm weather parameters. Of the fifteen missions alerted during the 1976-77 season, storm compatibility with the minimum intensity criteria was matched twice. In each of the two instances, the MSV was successfully launched.

2.5 POST LAUNCH CONDUCT

Following missile launch, in-situ and remote sampling of the storm was made to define its characteristics.

2.5.1 Data Collection

SPANDAR conducted its post-launch data gathering by examining the storm in the impact area, while the aircraft flew downstream from the impact area and sampled all altitudes by utilizing a spiraling descent.

2.5.2 Preliminary Analysis

A preliminary analysis to provide an initial environmental definition profile of water content was conducted by the FD and AFD as soon as accumulation of raw data terminated.

3.0 OPERATIONS

The initial phase of the FY76 operation was held 11-16 December 1975. All flights were of a training nature for aircrews and the various ground support elements; the first SAMS missile was ready for launch. The second phase, during which 3 SAMS launchings were effected, began 21 January 1976 and ended 25 April 1976. Tables 1 and A-I* summarize the passes.

After familiarization briefings, the operations for FY77 began, with a practice mission on 27 October 1976. The autumn phase ended with a MSV launch on 15/16 December and the winter phase ended with another MSV launch on 20 March 1977. The final airborne data was gathered 4 April 1977. Tables 2 and A-II* summarize the passes and the following text discusses these.

3.1 PRACTICE MISSIONS (FY77)

Practice missions were flown on 27 October, 2 November, and 18 November 1976. The 27 October and 2 November missions were only flown by the C-130. For its first flight of the FY77 season, the Learjet joined the C-130 for the practice mission of 18 November.

3.2 NOVEMBER-DECEMBER (1976) MISSIONS

During November and December 1976, six missions were flown culminating with the MSV missile launch of 15/16 December.

3.2.1 Single Aircraft Operations

The 12 November mission was flown by the C-130 which flew six runs correlated with SPANDAR, however, weather conditions did not warrant a missile launch. The 7 December mission was flown by the Learjet which completed 13 SPANDAR-correlated runs. Again, weather criteria for launch were not met. The 12 December mission was flown by the Learjet which completed 8 SPANDAR-correlated runs and initiated the technique of gathering additional data during 5 non-correlated

* In Appendix A

Table 1. FY76 Operations (Table entry is kilofeet; (n) is n passes)

TEMP (°C)	11 Dec	16 Dec	21 Jan	27 Jan	30 Jan	11 Feb	22 Feb	6 Mar	9 Mar	16 Mar	25 Mar	27 Mar	31 Mar	25 Apr
-45	3	28(2)							SAMS 1	30		SAMS 11		SAMS 111
-40	1	(1975)	(1976)							27				
-35	2	25(2)												
-30	11	22(2) 23(4)					23(2)			24		25		26
-25	15	19(4)	15(3)			22	23(2)		22	21(2)			24	24
-20	9				14				19	18	18(4)		21(2)	
-15	22	16(2) 18(2) 17(2)		17(2)	12 10(2) 9	16(2)			16		13(2) 19(2)		18(2)	20
-10	29	13(4) 16	7(2) 15(6)	15(6)		15(4) 12	15		14 13 10	12(2)		15	15(2) 16(2)	
-5	7	11(2)				9			7			12(2)		13
0	9	6(2)	10			6			1.55		5(2)	9(2)		
+5	2		7											8
+10	5			5 1.55 (2)								5(2)		
+15														

Table 2. FY77 Operations (Table entry is kilofeet; (n) is no. passes) ⁺

TEMP (°C)	TOTAL	12 Nov	26/27 Nov	29 Nov	7 Dec	12 Dec	15/16 Dec	9/10 Jan	24 Jan	24 Feb	27 Feb	4 Mar	6/7 Mar	13 Mar	18 Mar	20 Mar	22 Mar	4 Apr
-40	9					29	29 (1976)	26	30(3)							29(3)		
-35	9			30	26		28 27	27(2) 19		26						26		
-30	23			27	25	26	25(3)	24(2)		25(9)						25 26	26(2) 25(2)	
-25	19				23(2)	23	23(2) 22(4)	21(2)		22(2) 21		23(4)				23		
-20	17				20(3)	20		20 15(3)		19(2)		21 20				21(2)		
-15	37		19 16		17(2)	17(4)	19(3) 18(2)	18(5) 13(3)		16(3) 15		18(4)	19	20		19(3) 16	15 14	19 18(2)
-10	22		13		14(2)	14(2) 12* 15 15(2)* 14 16*		15(4)		13				15	15	13		
-5	28	6(5) 3		13	11(2)	11(2) 8	10(2) 13	12(3) 9(2)		10		14(2) 13		12	12	10	12	
0	16		10	10							2(2)			9	9(3)	1.5(2)	8 7 10	11
+5	15											7		6(2)	4(4)		9 3	12
+10	8											2(3)			3		2 1.5(3)	
+15	5						MSV ONE					2(2)		1.5(2)	1	MSV TWO		
+20																		

* Average of Climbing or Descending Pass

⁺ -40 to -60°C on following page

Table 2 (continued)

TEMP (°C)	12 Nov	26/27 Nov	7 Dec	12 Dec	15/16 Dec	9/10 Jan	24 Jan	24 Feb	27 Feb	4 Mar	6/7 Mar	13 Mar	18 Mar	20 Mar	22 Mar	4 Apr
-60	TOTAL				MSV ONE									MSV TWO		
-55	0															
-50	4					36(3)	36									
-45	9					33(4)	29(2) 31(2)							32		
-40	4					30(3)								28		

NOTE:

Main table entry is pass altitude in 1000's of feet;
parenthesized value is number of passes when more than one.

runs. Once more, weather was insufficient for launch. These non-correlated runs are initiated by the onboard meteorologist when at least 3 minutes of level flight were anticipated.

3.2.2 Two Aircraft Operations

Both aircraft flew on 26/27 November 1976, but only the C-130 recorded data during 4 SPANDAR-correlated runs; the weather was not adequate for a launch. On 29 November, the Learjet and the C-130 each made two SPANDAR-correlated runs; again, the weather failed to materialize.

3.2.3 December Launch

The storm of 15/16 December showed excellent promise and, after 3 SPANDAR-correlated runs by the Learjet and one by the C-130, the missile was launched at 2316 Z, 15 December 1976. Post launch sampling was completed approximately one hour later, on an UCT* (i.e., "GMT" or Zulu time zone) for 16 December.

3.3 JANUARY-APRIL (1977) MISSIONS

This period began with a mission on 9/10 January and ended with the final mission being flown 4 April. There was an absence of usable weather between 24 January and 24 February.

3.3.1 Single Aircraft Operations

The 27 February mission was flown by the C-130 which arrived from WPAFB in time to make two simulated beach passes. The surface winds were so high that the mission was cancelled before the Learjet took off. The mission of 6/7 March was also flown by the C-130. Again, weather failed to develop and, after one C-130 run before the Learjet took off, the mission was cancelled. The mission of 13 March found the C-130 enroute from WPAFB with weather criteria rapidly deteriorating. Strong south winds caused cancellation of missile

* Universal Coordinated Time

launch and Learjet take off. The C-130 completed 8 correlated runs before returning to Wright-Patterson Air Force Base. Since the weather missions following the MSV launch on 20 March were for a data uncertainty investigation, the 4 April mission was flown with the Learjet only, which completed 9 correlated runs.

3.3.2 Two Aircraft Operations

The 9/10 January operation was very long and the two aircraft provided 31 passes, 20 of which were SPANDAR-correlated over a 4.5 hour interval; 15 by C-130 and 5 by the Learjet. Nine of the 11 non-correlated passes were by the Learjet because of the light cloud at its altitude which provided marginal radar backscatter. This operation also tested the endurance aspect of the ground coordination system and procedures were reviewed in order to minimize the negative impacts on first time Learjet pilots.

The 24 January operation produced 6 SPANDAR-correlated passes by the C-130 and 7 by the Learjet. The 24 February mission was called off because of weather after 6 correlated runs by the C-130. Also, 4 correlated and 18 non-correlated runs were made by the Learjet. On 4 March, the C-130 flew 6 and the Learjet flew 4 correlated runs. During this mission, the Learjet also flew 9 non-correlated runs. High surface winds prevented missile launch. 18 March again found high winds preventing missile launch, but the C-130 flew 2 and the Learjet flew 7 correlated runs.

The Learjet also flew 11 non-correlated runs. On 22 March, with no missile to launch, both aircraft flew a data-gathering mission for an uncertainty investigation. The C-130 had 6 correlated runs, the Learjet 3. The final two correlated runs were made along airways because the storm dispersed over W-386. The Learjet also flew 10 non-correlated runs.

3.3.3 March (1977) Launch

The storm of 20 March developed as forecast, and the missile was launched at 1058Z. The C-130 flew 4 and the Learjet flew 6 correlated runs. The Learjet also flew 10 non-correlated runs. After splashdown, each aircraft sampled for a 16-minute spiral descent at 110 nm on the SPANDAR 093⁰ radial; the Learjet descending from FL360 to FL200 and the C-130 from FL230 to 6,000 feet.

3.3.4 Calibration Flights

Two non-weather missions were flown subsequent to the final missile launch of 20 March. On 28 March, the C-130 flew eastward through W-108 across Control area 1148, to 130 nm east of Snow Hill omni, then southwest via Snow Hill to central Virginia, in an altimeter/SPANDAR altitude check. On 29 March, the Learjet flew an airspeed calibration mission in W-386 using the C-130 as a control.

3.4 DATA GATHERING

Data gathering took many forms including airborne devices, disdrometers on the beach, Polaroid pictures of TV displays, and digital and voice tapes.

3.4.1 SPANDAR

SPANDAR data were recorded on tape by AFGL for reduction, also on tape by APL (during link mode sampling) for reduction and transmittal to AFGL, on Polaroid pictures of TV presentation of the displays, and on written logs.

3.4.2. Aircraft

Aircraft data were recorded by written logs, by voice tape, and by computer tape.

3.4.2.1 Airborne Collection

Voice tape recorders and digital data tape recorders were common to both aircraft. In addition, the following instrumentation was available on mission aircraft:

	<u>Learjet-36</u>	<u>AF C-130E</u>
1D Precipitation Probe	X	X
1D Droplet Probe	X	X
1D Axial Scatter Probe	X	X
2D Precipitation Probe	X	X
2D Droplet Probe	X	X
Formvar Replicator		X
Foil Sampler		X
Dew Point Hygrometer		X
Snow Stick	X	X
J-W LWC Meter	X	X
Water/Ice Content Instrument (EWER)		X
DEC PDP-8-E Computer Peripherals		X
Rosemount Temperature Probe	X	X
Total Water Content Indicator (TWCI)	X	

3.4.2.2 Tracking Radar

As requested, NASA - Wallops recorded tracking records of aircraft flights. Because of their backup status, none of these records were processed and distributed.

3.4.2.3 Plotboard Tracks

Pen traces on plotboard overlays for each mission are part of program records available at the Convective Cloud Physics Branch of AFGL.

3.4.3 Computers

3.4.3.1 Liquid Water Content Analyzer (LWCA)

This mini-computer based analyzer was used in conjunction with SPANDAR to assist the FD and AFD in decisions on storm suitability.

3.4.3.2 Antenna Programmer

This SPANDAR mini-computer provided rapid positioning of the antenna, with attendant maximum utilization of the radar.

3.4.3.3 Wallops Flight Center Tracking Data

These data were available as needed for mission accomplishment.

3.4.3.4 HP-65/67/9810

Utilizing small calculators, a computer program was developed by the FD and the AFD to assist in storm evaluation. It served as a backup to the LWCA. The HP-67 and 9810 versions by this author are a duplicate of the HP-65 original by Mr. V. G. Plank of the AFGL Convective Cloud Physics Branch.

3.4.4 GOES (Geostationary Operational Environmental Satellite)

This photofax service from the National Environmental Satellite Service (NESS) of NOAA, was installed in 1975 but did not provide a needed refinement - an enhanced infrared picture. To obtain such a picture, a special function generator was developed by AFGL after discussions with SAI. As it was being fitted to the photofax machine at Wallops in 1975, a parallel development by NESS was made available to the photofax subscribers, obviating the need for the SAI suggested hardware. Nevertheless, the AFGL system was easier to maintain at optimum display quality and was therefore used in FY76 and FY77.

The raw GOES data was simultaneously received by the MCIDAS installed at AFGL. A MCIDAS operator then processed the image brightness to produce ESI predictions which was in the region of primary interest for MSV targetting.

3.4.5 National Weather Service

The National Weather Service support of the program was outstanding. The following text is an abbreviated discussion of the NWS support because so much of it was by the qualitative capability of the NWS individuals.

3.4.5.1 NWS RADARS

Patuxent, Hatteras, and Tri-City radars provided the data that served as the foundation of the analysis of incoming weather.

3.4.5.2 RAOBS

In addition to excellent 12-hour soundings, the NWS station supplied special soundings as required by the MSV program. Special RAOBS were taken for twelve of the fifteen missions, several of them requiring two or more special releases.

3.4.5.3 Weather Briefings

As mentioned previously weather situation briefings were presented when requested by the program directors. Forecasts were realistic and accurate.

3.5 COMMUNICATIONS

As with almost any endeavor, success lies with the effectiveness of communications.

3.5.1 Commercial Telephones

The telephone was used extensively, to call up the missions, to confer with the various agencies involved, and to optimally utilize resources.

3.5.2 Air-to-Ground Radio

Both military and FAA, VHF and UHF channels were used to communicate between aircraft and the two ground stations, viz, "Wallops Plot" and "Wallops Weather", i.e., the Aircraft Coordinator and the AFD.

3.5.3 "Squawk Boxes"

Intercoms between SPANDAR and the WOCC, and between the AFGL FD office and Wright-Patterson Air Force Base, were installed and put to continuous use.

3.6 OTHER SUPPORT

In addition to the above cited support sources, certain other support was provided.

3.6.1 Cartography

AFGL provided the Lambert conformal maps necessary for the accuracy required by the program. For the longer ranges required by the MSV missions, a monograph* on the subject by A. A. Fletcher, Jr. of SAI, gained acceptance of the more accurate Lambert projection by the NASA personnel familiar with Mercator projections.

3.6.2 Reproduction

The reproduction of paperwork is a necessary burden, in this case borne by WFC. Charts and maps were expertly and expeditiously reproduced at the WFC Reproduction Shop. A xerox machine was available for the paperwork that required copying.

* Available with progress report No. 2 for period ending 30 April 1976.

3.6.3 Office Space

The NWS station personnel graciously relinquished table and desk space, as well as room for squawk boxes and a photofax machine, for this weather team.

4.0 CONCLUSIONS

4.1 OPERATIONS AND WEATHER PLAN

The Plan has been refined into a complete and detailed working plan, and could well serve as a model for any future endeavor of this nature.

4.2 COMMUNICATIONS FOR ASSEMBLY

The assembly of a diverse list of participants requires a rigid format for a "command of execution". The record shows that no mission was diluted by the absence of key personnel.

4.3 CONTROL CENTER LAYOUT

The Control Center layout has been adequate for the program, but some improvements are indicated:

- FD and AFD should be physically close enough to easily communicate by voice and use the graphic aids (e.g., wall maps).
- FD and AFD should be able to easily view the aircraft plotboard by looking straight ahead.
- The noise level during post launch operations should be reduced.
- Maps and charts should be made easier to see and to be read by the FD and AFD.

Appendix A

DETAILED PASS INFORMATION
FOR
FY76 AND FY77 OPERATIONS

TABLE A-I

DETAILED PASS INFORMATION FOR FY76 OPERATIONS

DATE	A/C	RUN	TIME (ZULU)		ALTITUDE (kft)	TEMP RANGE (°C)		RADAR CORRELATED
			START	STOP				
11 Dec 75	C-130A	1	1420	- 1422	28	-40→	-45	X
		2	1426	- 1430	25	-30→	-35	X
		3	1453	- 1456	22	-25→	-30	X
		4	1500	- 1505	19	-20→	-25	X
		5	1527	- 1532	28	-40→	-45	X
		6	1536:30	- 1539:50	25	-30→	-35	X
		7	1555	- 1601	22	-25→	-30	X
		8	1605	- 1609	19	-20→	-25	X
	C-130E	1	1436:06	- 1439	19	-20→	-25	X
		2	1443	- 1448	16	-10→	-15	X
		3	1511	- 1514	13	- 5→	-10	X
		4	1517	- 1522	13	- 5→	-10	X
		5	1541:30	- 1547	19	-20→	-25	X
		6	1552	- 1554	16	-10→	-15	X
		7	1610	- 1614	13	- 5→	-10	X
		8	1618	- 1621	13	- 5→	-10	X
16 Dec 75	L-36	1	1216	- 1220	18	-10→	-15	X
		2	1258	- 1318	17	-10→	-15	X
		3	1412	- 1417	23	-25→	-30	X
		4	1420	- 1424	23	-25→	-30	X
		5	1529	- 1534	11	0 →	- 5	X
		6	1537	- 1547:30	6	+ 5→	0	X
	C-130E	1	1202:30	- 1206:30	18	-10→	-15	X
		2	1224	- 1230:30	16	- 5→	-10	X
		3	1324	- 1345	17	-10→	-15	X
		4	1429	- 1431	23	-25→	-30	X
		5	1434	- 1438	23	-25→	-30	X
		6	1501	- 1507	11	0 →	- 5	X
		7	1510:30	- 1522:30	6	+ 5→	0	X
21 Dec 75	C-130E	1	2125	-	15	-20→	-25	X
		2	2140	-	15	-20→	-25	X
		3	2204	-	15	-20→	-25	X
		4	2233	-	7	- 5→	-10	X
		5	2248	-	7	- 5→	-10	X
27 Jan 76	C-130E	1	1313	- 1318	15	- 5→	-10	X
		2	1338	- 1352	15	- 5→	-10	X
		3	1356	- 1410	15	- 5→	-10	X
		4	1418	- 1438	15	- 5→	-10	X
		5	1441	- 1447	1.5	+10→	+15	X

TABLE A-I (continued)

DATE	A/C	RUN	TIME (ZULU)		ALTITUDE (kft)	TEMP RANGE (°C)		RADAR CORRELATED
			START	STOP				
	C-130A	1						
		2	2108	- 2125	15	- 5→	-10	X
		3	2131	- 2137	15	- 5→	-10	X
		4	2142	- 2157	15	- 5→	-10	X
		5	2202:30	- 2211:30	17	-10→	-15	X
		6	2217	- 2237	17	-10→	-15	X
		7	2249	- 2320	10	0 →	+ 5	X
		8	2326	- 2338	7	+ 5→	+10	X
30 Jan 76	C-130A	1	2321:45	- 2330	10	-10→	-15	X
	C-130E	1	2150	- 2205	9	-10→	-15	X
		2	2230	- 2247	12	-10→	-15	X
		3	2300	- 2306	14	-15→	-20	X
		4	2338	- 2343	10	-10→	-15	X
11 Feb 76	C-130A	1	1455	- 1505	15	- 5→	-10	X
		2	1508	- 1514	15	- 5→	-10	X
		3	1518	- 1526	15	- 5→	-10	X
		4	1543	- 1552	22	-20→	-25	X
		5	1559	- 1604	16	-10→	-15	X
		6	1606	- 1620	16	-10→	-15	X
		7	1622	- 1626	15	- 5→	-10	X
		8	1630	- 1634	12	- 5→	-10	X
		9	1637	- 1641	9	0 →	- 5	X
		10	1647	- 1651	6	+ 5→	0	X
22 Feb 76	C-130A	1	1527	- 1534	23	-25→	-30	X
		2	1537	- 1544	23	-25→	-30	X
6 Mar 76	C-130A	1	0157:30	- 0203	15	- 5→	-10	X
	C-130E	1	0140	- 0149:53	23	-20→	-25	X
		2	0154	- 0156:30	23	-20→	-25	X
9 Mar 76	C-130A	1	1428:50	- 1433:30	14	- 5→	-10	X
	C-130E	1	1330	- 1335	22	-20→	-25	X
		2	1339:20	- 1343:30	19	-15→	-20	X
		3	1347:30	- 1355:30	16	-10→	-15	X
		4	1359:30	- 1403:30	13	- 5→	-10	X
		5	1407:30	- 1410	10	- 5→	-10	X
		6	1417	- 1421	7	0 →	- 5	X
		7	1438:30	- 1442	1.5	+ 5→	0	X
16 Mar 76	C-130A	1	1651:30	- 1655:30	30	-40→	-45	X
		2	1701+	- 1706:30	27	-35→	-40	X
		3	1732	- 1736	24	-25→	-30	X
		4	1740	- 1744:30	21	-20→	025	X

TABLE A-1 (continued)

<u>DATE</u>	<u>A/C</u>	<u>RUN</u>	<u>TIME</u> <u>START</u>	<u>(ZULU)</u> <u>STOP</u>	<u>ALTITUDE</u> <u>(kft)</u>	<u>TEMP</u>	<u>RANGE</u> <u>(°C)</u>	<u>RADAR</u> <u>CORRELATED</u>
	C-130E	1	1711:30	- 1716	21	-20→	-25	X
		2	1720	- 1724	18	-15→	-20	X
		3	1752	- 1756	12	- 5→	-10	X
		4	1801	- 1805	12	- 5→	-10	X
25 Mar 76	C-130A	1	1949	- 1955	18	-15→	-20	X
		2	2012	- 2019	13	-10→	-15	X
		3	2040:30	- 2047	18	-15→	-20	X
		4	2100	- 2105	5	+ 5→	0	X
	C-130E	1	1938	- 1946	18	-15→	-20	X
		2	2000	- 2008	13	-10→	-15	X
		3	2031	- 2037	18	-15→	-20	X
		4	2050	- 2055	5	+ 5→	0	X
27/28 Mar 76	C-130A	1	2314:46	- 2318	25	-25→	-30	X
		2	2323:30	- 2327:30	19	-10→	-15	X
		3	2347:34	- 2351	19	-10→	-15	X
		4	2356:30	- 0000:30	15	- 5→	-10	X
		5	0012	- 0016	12	0 →	- 5	X
		6	0020	- 0023	9	+ 5→	0	X
		7	0028	- 0032	5	+10→	+15	X
	C-130E	1	2331:33	- 2335	12	0 →	- 5	X
		2	2339:40	- 2343	9	+ 5→	0	X
		3	0006	- 0010	5	+10→	+15	
31 Mar 76	C-130E	1	1832	- 1838	24	-20→	-25	X
		2	1841	- 1846	21	-15→	-20	X
		3	1851	- 1855	21	-15→	-20	X
		4	1859	- 1903	18	-10→	-15	X
		5	1910	- 1914	18	-10→	-15	X
		6	1921	- 1925	15	- 5→	-10	X
		7	1930	- 1934	15	- 5→	-10	X
25 Apr 77	C-130A	1	2116	- 2118	26	-25→	-30	X
		2	2122	- 2129	24	-20→	-25	X
		3	2144:30	- 2148:30	20	-10→	-15	X
		4	2158	- 2202	16	- 5→	-10	X
	C-130E	1	2134	- 2138	16	- 5→	-10	X
		2	2153	- 2157	13	0 →	- 5	X
		3	2205	- 2210	8	+ 5→	+10	X

Table A-II
DETAILED PASS INFORMATION FOR FY77 OPERATIONS

DATE	A/C	RUN	TIME (ZULU)		ALTITUDE (kft)	TEMP RANGE (°C)	RADAR CORRELATED
			START	STOP			
12 NOV 76	C-130E	1	1417	- 1427	6	0 → -5	X
		2	1430	- 1435	6	0 → -5	X
		3	1439	- 1443	6	0 → -5	X
		4	1446	- 1454	6	0 → -5	X
		5	1533	- 1551:30	6	0 → -5	X
		6	1557	- 1602	3	0 → -5	X
26/27 NOV 76	C-130E	1	0639	- 0645	10	+5 → 0	X
		2	0654	- 0701	13	-5 → -10	X
		3	0707	- 0713	16	-10 → -15	X
		4	0724	- 0730	19	-10 → -15	X
29 NOV 76	L-36	1	0508	- 0511	30	-30 → -35	X
		2	0522	- 0526	27	-25 → -30	X
	C-130E	1	0501	- 0507	10	+5 → 0	X
		2	0527	- 0533	13	0 → -5	X
7 DEC 76	L-36	1	1029:30-	1038	26	-30 → -35	X
		2	1043	- 1047	23	-20 → -25	X
		3	1054	- 1058	20	-15 → -20	X
		4	1104	- 1108	17	-10 → -15	X
		5	1125:30-	1130:30	20	-15 → -20	X
		6	1141:30-	1145:30	14	-5 → -10	X
		7	1151	- 1156	11	0 → -5	X
		8	1204	- 1208	11	0 → -5	X
		9	1212:30-	1216:30	14	-5 → -10	X
		10	1220	- 1230	17	-10 → -15	X
		11	1235:30-	1239:30	20	-15 → -20	X
		12	1242:30-	1247	23	-20 → -25	X
		13	1249:30-	1252	25	-25 → -30	X
12 DEC 76	L-36	1	1001	- 1005	29	-35 → -40	X
		2	1028:30-	1032:30	26	-25 → -30	X
		3	1037:30-	1041:30	23	-20 → -25	X
		4	1050:30-	1055	20	-15 → -20	X
		5	1105	- 1106	17	-10 → -15	
		6	1111:30-	1115	17	-10 → -15	
		7	1119	- 1123	17	-10 → -15	
		8	1127	- 1132	14	-5 → -10	
		9	1138:30-	1143:30	11	0 → -5	
		10	1148	- 1152	8	0 → -5	X
		11	1156	- 1200	11	0 → -5	X
		12	1202	- 1205	14	0 → -5	X
		13	1207	- 1210	17	-10 → -15	X

TABLE A-II (cont.)
DETAILED PASS INFORMATION FOR FY77 OPERATIONS

DATE	A/C	RUN	TIME (ZULU) START - STOP	ALTITUDE (kft)	TEMP RANGE (°C)	RADAR CORRELATED
15/16 DEC 76	L-36	1	2209 - 2217	25	-25 → -30	
		2	2217 - 2221	25	-25 → -30	X
		3	2227 - 2230:30	22	-20 → -25	X
		4	2235:30 - 2240	19	-10 → -15	
		5	2242 - 2244:30	19	-10 → -15	X
		6	2250 - 2253:30	25	-25 → -30	
		7	2256 - 2259	29	-35 → -40	
		8	2332:30 - 2336:30	22	-20 → -25	
		9	2347 - 2349:30	22	-20 → -25	
		10	2351:30 - 2353	22	-20 → -25	
		11	2355 - 2357	23	-20 → -25	
		12	0000 - 0002	28	-30 → -35	
		13	0004 - 0006	27	-30 → -35	
		14	0008 - 0010	23	-20 → -25	
		15	0012 - 0014	19	-10 → -15	
		16	0016 - 0018	14	-5 → -10	
		17	0020:30 - 0023:30	13	0 → -5	
		18	0026 - 0038	15	-5 → -10	
	C-130E	1	2235 - 2239	10	0 → -5	X
		2	2340 - 2348	10	0 → -5	
		3	2348 -	10		
			CLIMB (ORBIT)	15*	-5 → -10	
			- 0001	20		
		4	0001 -	20		
			DESCEND	15*	-5 → -10	
			- 0020	10		
		5	0020 -	10		
			CLIMB	12*	-5 → -10	
			- 0031	14		
		6	0031 -	14		
			CLIMB	16*	-5 → -10	
			- 0039	18		
		7	0039 - 0047	18	-10 → -15	
		8	0047 - 0116	18	-10 → -15	

* Average of Climbing or Descending Pass

Table A-II (cont.)
DETAILED PASS INFORMATION FOR FY77 OPERATIONS

DATE	A/C	RUN	TIME (ZULU) START - STOP	ALTITUDE (kft)	TEMP (°C)	RANGE	RADAR CORRELATED
9/10 JAN 77	L-36	1	0010 - 0014	36	-50	-55	
		2	0020:30-0024:30	33	-45	-50	
		3	0028 - 0032	33	-45	-50	X
		4	0038 -0042:15	30	-40	-45	
		5	0044:30-0048:30	20	-15	-20	X
		6	0102:30-0106:30	36	-50	-55	
		7	0013 -0017:30	33	-45	-50	
		8	0126 - 0130	30	-40	-45	X
		9	0141 - 0145	27	-30	-35	X
		10	0156 - 0200	27	-30	-35	
		11	0214 - 0218	24	-25	-30	X
		12	0241 - 0245	36	-50	-55	
		13	0253 - 0258	33	-45	-50	
		14	0308 - 0312	30	-40	-45	
	C-130E	1	2320 - 2329	24	-25	-30	X
		2	2347 - 2353	21	-20	-25	X
		3	0008 - 0014	18	-10	-15	X
		4	0038 - 0043	15	-5	-10	X
		5	0104 - 0109	21	-20	-25	X
		6	0117 - 0121	18	-10	-15	X
		7	0131 - 0136	15	-5	-10	X
		8	0154:30-0158:30	12	-5	-10	X
		9	0214 - 0226	18	-10	-15	
		10	0233 - 0237	18	-10	-15	X
		11	0240 - 0244	15	-5	-10	X
		12	0253 - 0258	12	-5	-10	X
		13	0308 - 0312	9	0	-5	
		14	0318 - 0324	9	0	-5	X
		15	0327:30-0331:30	12	-5	-10	X
		16	0341 - 0345	15	-5	-10	X
		17	0350:30- 0356	18	-10	-15	X
24 JAN 77	L-36	1	1854:30- 1856	31	-45	-50	
		2	2901 - 1907	29	-45	-50	X
		3	1911 - 1916	26	-35	-40	X
		4	1921 - 1924	29	-45	-50	
		5	1927 -1929:30	31	-45	-50	
		6	1935:30- 1936	36	-50	-55	
		7	1946 - 1949	19	-20	-25	
		8	1957 - 2001	13	-5	-10	X
		9	2004 -2005:30	15	-10	-15	
		10	2007:30-2012:30	15	-10	-15	
		11	2019 - 2023	13	-5	-10	X
		12	2050 - 2054	13	-5	-10	
		13	2057:30-2100:30	15	-10	-15	

Table A-II (cont.)
DETAILED PASS INFORMATION FOR FY77 OPERATIONS

DATE	A/C	RUN	TIME (ZULU) START - STOP	ALTITUDE (kft)	TEMP (°C)	RANGE	RADAR CORRELATED
24 FEB 77	L-36	1	1956:20-1959:20	30	-35 → -40		
		2	2003 - 2006	30	-35 → -40		
		3	2023:30-2026:30	25	-25 → -30		
		4	2027:45-2030:45	25	-25 → -30		
		5	2035:30-2038:30	25	-25 → -30		
		6	2049:40-2052:40	25	-25 → -30		
		7	2055:30-2059:30	25	-25 → -30		
		8	2100:30-2103:30	25	-25 → -30		X
		9	2108:30-2111:30	22	-20 → -25		
		10	2118 - 2122	22	-20 → -25		X
		11	2128:30-2131:30	19	-15 → -20		
		12	2133:30-2137:30	19	-10 → -15		X
		13	2149 - 2152	16	-10 → -15		
		14	2155 - 2157	16	-10 → -15		
		15	2318:30-2322:30	30	-35 → -40		
		16	2325:35-2326:30	26	-25 → -30		
		17	2330:45-2334:45	25	-25 → -30		X
		18	2338 - 2341	25	-25 → -30		
	C-130E	1	2055:30-2059:30	10	0 → -5		X
		2	2112:30-2116:30	13	-5 → -10		X
		3	2128:30-2132:30	16	-10 → -15		X
		4	2155 - 2159	13	-5 → -10		X
		5	2224 - 2232	21	-20 → -25		X
		6	2315 - 2320:30	25	-25 → -30		X
27 FEB 77	C-130E	1	2218 - 2223:30	2	+15 → +20		X
		2	2233 - 2239	2	+15 → +20		X
4 MAR 77	L-36	1	2057:30-2104:30	2	+10 → +15		X
		2	2116 - 2120	2	+10 → +15		X
		3	2118 - 2132	14	0 → -4		
		4	2143 - 2146	18	-5 → -10		
		5	2148 - 2152	18	-5 → -10		
		6	2154 - 2158	18	-10 → -15		
		7	2202 - 2205	20	-15 → -20		
		8	2206 - 2210	23	-15 → -20		X
		9	2215 - 2220	23	-15 → -20		X
		10	2226 - 2230	21	-15 → -20		
		11	2236 - 2240	13	0 → -5		
		12	2243 - 2247	7	+5 → +10		
		13	2250 - 2253	2	+10 → +15		
	C-130E	1	2005 - 2010	2	+15 → +20		X
		2	2022 - 2028	2	+15 → +20		X
		3	2044 - 2048	14	0 → -5		X
		4	2131 - 2140	23	-20 → -25		X
		5	2153 - 2158	23	-20 → -25		X
		6	2235 - 2239	18	-10 → -15		X

Table A-II (cont.)
DETAILED PASS INFORMATION FOR FY77 OPERATIONS

DATE	A/C	RUN	TIME (ZULU) START - STOP	ALTITUDE (kft)	TEMP. RANGE (°C)	RADAR CORRELATED
6/7 MAR 77	C-130E	1	0343 - 0347	19	-10 → -15	X
13 MAR 77	C-130E	1	1430 - 1440	9	0 → +5	X
		2	1442 - 1446	6	+5 → +10	X
		3	1450 - 1457	6	+5 → +10	X
		4	1509 - 1515	12	0 → -5	X
		5	1521 - 1529	15	-5 → -10	X
		6	1545 - 1555	1.5	+15 → +20	X
		7	1606:30- 1613	1.5	+15 → +20	X
		8	1638 - 1658	20	-10 → -15	X
18 MAR 77	L-36	1	1847:46-1849:40	15	-5 → -10	
		2	1902 - 1904	12	0 → -5	
		3	1925:10-1927:06	9	0 → +5	
		4	1929:11-1935:30	9	0 → +5	
		5	1939 - 1942	9	0 → +5	X
		6	1952 - 1956	4	+10 → +15	
		7	2002:35-2005:27	4	+10 → +15	X
		8	2009 -2014:30	4	+10 → +15	X
		9	2030 - 2035	4	+10 → +15	X
		10	2040:24- 2043	3	+10 → +15	
		11	2048:24-2049:39	1	+15 → +20	
20 MAR 77	L-36	1	0846:34-0850:15	25	-25 → -30	
		2	0856:43-0901:30	28	-40 → -45	
		3	0908:30-0912:30	32	-45 → -50	X
		4	0916 - 0919	29	-35 → -40	
		5	0923 -0923:46	29	-35 → -40	
		6	0928 - 0932	29	-35 → -40	X
		7	0938:47-0941:30	26	-25 → -30	
		8	0943 - 0947	26	-30 → -35	X
		9	0957 - 1001	23	-20 → -25	X
		10	1004:30-1007:15	21	-15 → -20	
		11	1010 - 1014	21	-15 → -20	X
		12	1021:30-1025:30	19	-15 → -20	X
		13	1031:45-1035:16	19	-15 → -20	
	C-130E	1	0917 - 0921	10	0 → -5	X
		2	0937:30-0941:30	13	-5 → -10	X
		3	0952 - 0956	16	-10 → -15	X
		4	1005:30-1009:30	19	-15 → -20	X
		5	1208 - 1213	1.5	0 → +5	X
		6	1213 - 1219	1.5	0 → +5	X

Table A-II (cont.)
DETAILED PASS INFORMATION FOR FY77 OPERATIONS

DATE	A/C	RUN	TIME (ZULU) START - STOP	ALTITUDE (kft)	TEMP. RANGE (°C)	RADAR CORRELATED
22 MAR 77	L-36	1	1444:50- 1446	5	+5 → +10	
		2	1448:30- 1451	5	+5 → +10	
		3	1456:24-1459:24	2	+10 → +15	
		4	1504:13-1507:36	1.4	+10 → +15	X
		5	1530:45-1532:39	7	+5 → +10	
		6	1539:32- 1547	5	+5 → +10	X
		7	1552:41-1554:31	5	+5 → +10	
		8	1611:22-1613:45	5	+5 → +10	
		9	1640:55-1644:24	15	-10 → -15	
		10	1646:20-1648:25	14	-10 → -15	
		11	1654 - 1701	9	0 → -5	X
		12	1705:33-1707:39	9	+5 → 0	
		13	1710:44-1713:41	8	+5 → 0	
	C-130E	1	1413:30-1419:20	1.5	+10 → +15	X
		2	1433:30-1438:10	5	+5 → +10	X
		3	1457 - 1501	1.5	+10 → +15	X
		4	1521:30- 1530	5	+5 → +10	X
		5	1552:30-1554:30	3	+5 → +10	X
		6	1639:30-1644:30	12	0 → -5	X
4 APR 77	L-36	1	1528 - 1529	18	-10 → -15	
		2	1535:32-1539:30	25	-25 → -30	X
		3	1542:29-1545:38	25	-25 → -30	X
		4	1606:29-1610:38	26	-25 → -30	X
		5	1615 - 1619	26	-25 → -30	X
		6	1632 -1635:31	18	-10 → -15	X
		7	1638:11- 1642	19	-10 → -15	X
		8	1655 - 1659	12	0 → +5	X
		9	1700 - 1704	11	0 → +5	X
		10	1706:30-1710:27	10	0 → +5	X